ISSN 0018-151X, High Temperature, 2018, Vol. 56, No. 4, pp. 481–485. © Pleiades Publishing, Ltd., 2018.
Original Russian Text © A.L. Tukmakov, N.F. Kashapov, D.A. Tukmakov, M.G. Fazlyyyakhmatov, 2018, published in Teplofizika Vysokikh Temperatur, 2018, Vol. 56, No. 4, pp. 498–502.

PLASMA INVESTIGATIONS

Process of the Deposition of Charged Polydisperse Gas Suspension on the Plate Surface in an Electrical Field

A. L. Tukmakov[a, b, *], N. F. Kashapov[c, **], D. A. Tukmakov[a, b], and M. G. Fazlyyyakhmatov[c, *]**

[a] *Kazan Tupolev National Technical Research University, Kazan, 420111 Russia*
[b] *Institute of Mechanics and Engineering, Kazan Scientific Center, Russian Academy of Sciences, Kazan, 420029 Russia*
[c] *Kazan (Volga Region) Federal University, Kazan, 420008 Russia*
**e-mail: tukmakov@imm.knc.ru*
***e-mail: Nail.Kashapov@kpfu.ru*
****e-mail: mfazlyjy@kpfu.ru*

Received October 3, 2017

Abstract—The process of powder sputtering onto a flat surface in an electric field is described on the basis of the numerical solution of a system of equations of the dynamics of a polydisperse gas suspension. The model includes equations for the motion of the carrier and disperse phases under the action of the aerodynamic friction force and the Coulomb force, taking into account the interphase exchange of momentum and energy. The system is solved by the explicit predictor–corrector method with splitting over the spatial directions and the nonlinear correction scheme. The numerical model is used to obtain the velocity and density fields of the gas suspension in the interelectrode space and on the surface of the target electrode.

DOI: 10.1134/S0018151X18040193

INTRODUCTION

Physical and numerical simulation of the electrogas dynamics of disperse systems, including gas suspensions, as well as vapor and bubble media, is of interest due to the practical application of research results to various technical devices in which the presence of a disperse phase substantially changes the nature of the processes and the range of operating parameters [1] and the improvement of such technologies as industrial gas purification, the separation of components with various dielectric and magnetic properties, and the deposition of polymer coatings. The electro- and gas dynamics of disperse systems are studied both by experimental and numerical methods. Thus, features of the architecture of the program complex for the simulation of the flows of charged particles in the electrostatic approximation have been described [2]. The Euler–Lagrangian particle methods of solving the Vlasov–Poisson equation are used for the simulation. A self-consistent model of a glow discharge burning in the regime of normal current density and the dust particles placed in it was studied [3]. A mathematical model of nonmagnetized multicomponent plasma [4], which includes ions and electrons, as well as negatively charged large dust particles, was proposed.

In this paper, the dust plasma model is used to describe the motion of a charged gas suspension in a carrier medium under the effect of aerodynamic and electric forces [5, 6] with respect to the technology of powder coloration. To simulate the formation of a deposited layer, it is necessary to solve the problem of the motion of charged aerosol particles in the space between the nozzle-atomizer, which is fed with a negative potential, and the surface to be colored, the potential of which is positive or zero. In the polydisperse composition of the powdered dye particles, their motion in the interelectrode space depends on the value of the charge, the aerodynamic resistance of the particles, the location of the electrodes, the electric field strength, and the velocity and concentration of solid fractions.

MATHEMATICAL MODEL

The process model can be based on a system of equations of the motion of a multivelocity multitemperature medium [7], in which the particle is affected by forces of an aerodynamic nature and the Coulomb force. The system of equations includes equations of the motion of the carrier medium and fractions of the disperse phase; it takes into account the interphase force interaction and heat transfer, as well as the interaction of the charged gas suspension with the electric field, which is created by both stationary electrodes and the spatially distributed electric charge transferred by the disperse phase [8–10]:

$$\frac{\partial \rho}{\partial t} + \frac{\partial (\rho u)}{\partial x} + \frac{\partial (\rho v)}{\partial y} = 0,$$